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Short Communication

Effective household disinfection methods of kitchen sponges

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ABSTRACT

Several household disinfecting treatments to reduce bacteria, yeasts and molds on kitchen sponges were evaluated. Sponges were soaked in 10% bleach solution for 3 min, lemon juice (pH 2.9) for 1 min, or deionized water for 1 min, placed in a microwave oven for 1 min at full power, or placed in a dishwasher for full wash and drying cycles, or left untreated (control). Microwaving and dishwashing treatments significantly lowered ($P < 0.05$) aerobic bacterial counts (<0.4 log and 1.6 log CFU/sponge, respectively) more than any chemical treatment or control (7.5 CFU/sponge). Counts of yeasts and molds recovered from sponges receiving microwave (<0.4 log CFU/sponge) or dishwashing (0.4 log CFU/sponge) treatments were significantly lower than those recovered from sponges immersed in chemical treatments. Our study shows that microwaving and dishwashing treatments may kill foodborne pathogens in a household kitchen environment.

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1. Introduction

Cross contamination of foodborne pathogens in the household kitchen may contribute to the estimated 76,000,000 cases of foodborne illness in the US, each year (Mead et al., 1999). Improper domestic food handling and unhygienic practices are thought to be a major factor in sporadic cases of foodborne illness. It is estimated that up to 87% of foodborne disease outbreaks that occurred in the United Kingdom, Europe, Australia, New Zealand, the United States, and Canada originated from food prepared or consumed in the home (Redmon & Griffith, 2003).

Kitchen sponges deserve attention in the household because they can remain wet and serve as a reservoir and vehicle for foodborne pathogens to cause illness. Kitchen sponges used to wash dishes containing foodborne pathogens transferred *Escherichia coli* O157:H7 to surfaces more frequently than *Salmonella* spp. (Mattick et al., 2003). Sponges contaminated with *Staphylococcus aureus, Salmonella enteritidis*, and *Campylobacter jejuni* were able to transfer pathogens to stainless steel surfaces, where *S. aureus* survived for up to 4 days. Similarly, pathogens transferred by sponges to stainless steel surfaces were subsequently transferred to cut vegetables at varying rates (Kusumaningrum, Riboldi, Hazeleger, & Beumer, 2003). In a study of ten kitchens in the US, 33% and 67% of sponges tested positive for *E. coli* and fecal coliforms, respectively (Josephson, Rubino, & Pepper, 1997).

Limiting the ability of sponges to disseminate pathogens is crucial to food safety as several studies have shown the presence of these pathogens in household kitchens. Gram positive pathogens (*S. aureus, Bacillus cereus*) have been more frequently isolated from dry surfaces in households than Gram negative bacteria (Beumer & Kusumaningrum, 2003). *Listeria monocytogenes* was found in 21% of households in the Netherlands, with the most common source identified as wet dish cloths (Beumer, Te Giffel, Spoorenberg, & Rombouts, 1996). An examination of 342 household refrigerators in Ireland determined total viable and total coliform counts as high as 8.8 and 6 log CFU/cm^2, respectively (Jackson, Blair, McDowell, Kennedy, & Bolton, 2007). This same study also reported low incidences of the psychrotrophic pathogens *L. monocytogenes* and *Yersinia enterocolitica*. Other studies have established that areas that were moist or frequently touched by human hands (sponges, dishcloths, kitchen faucet handles, and kitchen sink drains) had higher numbers of fecal coliform, coliform, and heterotrophic bacteria than other areas in the kitchen (Rusin, Orosz-Coughlin, & Gerba, 1998). Norovirus, the leading cause of viral foodborne illness in the US, inoculated on a variety of surfaces persists for up to 7 days and was transferred to lettuce leaves at levels that may cause illness (D'Souza et al., 2006). Foodborne pathogens can persist in a kitchen environment, and they may be spread using kitchen sponges unless properly disinfected.

S. aureus and *C. jejuni* were isolated from the preparers' hands, oven handles, counter-tops, and cutting boards, while *Salmonella* spp. were isolated in 25 different households from used dishcloths after the preparation of chickens for cooking (Gorman, Bloomfield, & Adley, 2002). In a controlled study in the United Kingdom, up to

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35% of chickens purchased at retail were contaminated with both *Salmonella* and *C. jejuni* (Cogan, Bloomfield, & Humphrey, 1999), providing another route that foodborne pathogens can enter household kitchens. In two studies, *Salmonella spp.* were isolated from 13.8% of dishcloths and 15.4% of sponges taken from US households (Enriquez, Eniquez-Gordillo, & Gerba, 1997), while *S. aureus* was found in 4% of sponge-type dishcloths (Hilton & Austin, 2000). Inconsistent hand washing between handling meat and non-meat items was associated with higher risk of sporadic salmonellosis (Kohl, Rietberg, Wilson, & Farley, 2002). Other work has shown that a targeted disinfection program may reduce foodborne illnesses and costs due to medical treatment and lost productivity (Duff et al., 2003). Disinfection of sponges may prevent the survival and spread of pathogens in the kitchen. As lifestyles change, individuals spend less time in the kitchen preparing meals and subsequently give less attention to proper food handling and sanitation practices that can reduce foodborne illness and spoilage of food. Simple, fast, and effective methods to disinfect kitchen sponges may prevent the spread of spoilage and pathogenic microorganisms in household kitchens, and may lead to better food preservation and fewer cases of foodborne illness.

The purpose of this experiment was to determine the most effective and rapid method available to a household to disinfect a heavily contaminated kitchen sponge.

2. Methods

2.1. Preparation and inoculation of sponges

Commercial sponges (119 mm × 76 mm × 15 mm) without scrub pads were purchased, removed from the original packaging and cut with sterile scissors so each sponge measured 60 mm × 38 mm × 15 mm. Lean (90%) ground beef (454 g), purchased at a local grocery store, was mixed with 1300 ml of tryptic soy broth (TSB, Becton Dickinson) in a stomacher (Interscience) for 2 min to create a ground beef slurry. Using sterile forceps, sponges were placed in a sterile test tube rack in a sterile plastic tub. The test tube rack was used to hold the sponges apart for uniform inoculation. The ground beef slurry was then poured evenly over the sponges in the test tube rack, after which 2700 ml of TSB was added. The tub was covered with aluminum foil and sponges were incubated in this slurry for 48 h at room temperature (22 °C).

2.2. Disinfection of sponges with chemical treatments

After incubation, sponges were removed from the ground beef slurry with sterile forceps, and excess slurry was allowed to drip off sponges before being fully immersed without agitation or squeezing into a sterile beaker containing 500 ml of either sterile deionized water, single strength lemon juice (Real Lemon, pH 2.9), or a 10% solution of household bleach (Clorox, 5.25% sodium hypochlorite). Sponges in lemon juice or water were exposed for 1 min to the treatment, while sponges in 10% bleach were exposed for 3 min. Sponges were then placed in 40 ml of 1 X Dey Engley (DE) broth (Becton Dickinson) contained in a stomacher bag and squeezed to neutralize the effects of residual disinfecting solutions and distribute the DE throughout the sponge. Untreated (control) sponges receiving no chemical treatments were placed directly into DE broth.

2.3. Disinfection of sponges by microwave and dishwashing treatment

Inoculated sponges in a sterile beaker were placed on the turntable of a household microwave oven (Emerson, model MW8780SB) with a frequency of 2,450 MHz and 1.30 kW for 1 min at full power and then immediately transferred to DE broth. For dishwashing treatments, inoculated sponges were placed in the top rack of a household dishwasher (portable-convertible model, General Electric) and a normal cycle with the water temperature boost feature and heated drying cycle was executed. No dishwashing detergent was added during this treatment. Immediately after the cycle ended, the sponges were placed into DE broth.

2.4. Microbiological analysis

Sponges transferred to the DE broth were stomached for 2 min to agitate microorganisms from sponges into the broth. Undiluted suspensions or serial dilutions (0.1 ml, in duplicate) of DE broth in 0.1% peptone water were spiral-plated (Don Whitley Scientific) on tryptic soy agar (TSA, Becton Dickinson) to determine aerobic bacterial populations. Suspensions and serial dilutions were plated on Dichloran Rose Bengal Chloramphenicol agar (DRBC, Becton Dickinson) to determine counts of yeasts and molds. TSA plates were incubated at 37 °C for 24 h before enumeration; DRBC plates were incubated at 25 °C for 5 days before enumeration.

2.5. Statistical analysis

Three replicates of each experiment were performed. Statistical Analysis Software version 9.1 (SAS,) was used to conduct an analysis of variance and least significant difference mean separation tests ($P \leqslant 0.05$).

3. Results

Untreated (control) sponges receiving no disinfecting treatment had total counts of 7.5 CFU (colony forming units) of aerobic bacteria/sponge and 7.3 CFU of yeasts and mold/sponge. Microwave treatment of heavily contaminated kitchen sponges was the most effective method to kill bacteria, with less than 0.4 log CFU/sponge surviving 1 min of exposure, significantly ($P < 0.05$) less than any other treatment evaluated (Fig. 1). Dishwashing treatment was significantly more effective than 10% bleach, lemon juice or water applied to sponges, with 1.8 log CFU/sponge surviving after treatment. Among chemical treatments, sponges soaked in 10% bleach had populations only 0.3 and 0.5 log CFU/sponge lower than those soaked in water or lemon juice, respectively.

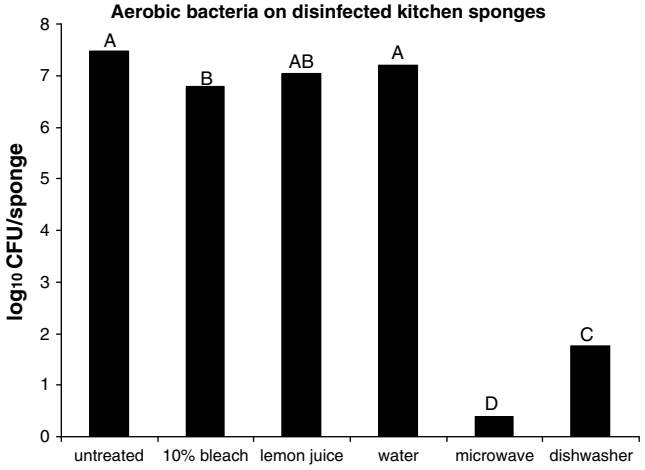

Fig. 1. Recovery of aerobic bacteria (log CFU/sponge) following disinfection treatments of kitchen sponges. Different letters above bars indicate statistically significant differences ($P < 0.05$) in populations of aerobic bacteria as affected by household disinfection treatment.

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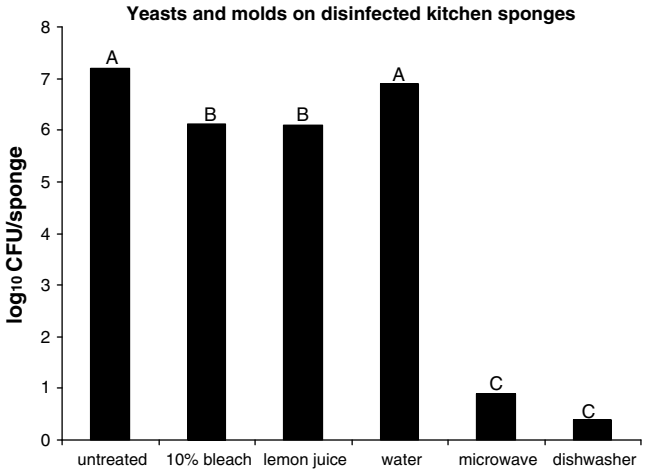

Fig. 2. Recovery of yeasts and molds (log CFU/sponge) on disinfected kitchen sponges. Different letters above bars indicate statistically significant differences ($P < 0.05$) in population of yeasts and molds as affected by household disinfection treatment.

Significantly lower numbers of yeasts and molds survived on sponges treated in the microwave or dishwasher (0.9 and 0.4 log CFU/sponge, respectively) than sponges exposed to chemical treatments (Fig. 2). Unlike with bacteria, there was no statistically significant difference between microwaving and dishwashing treatments. Soaking sponges in 10% bleach for 3 min or lemon juice for 1 min significantly lowered counts of yeasts and molds (6.1 and 6.1 log CFU/sponge), compared to counts on sponges soaked in water (6.9 log CFU/sponge).

4. Discussion

The sodium hypochlorite in the bleach solution may have been inactivated by the presence of organic soils present on these sponges, which diminished the the microbiocidal effect of the treatment. Hypochlorite solutions are readily inactivated and rendered less effective in the presence of organic material such as meat tissues and protein (Kotula, Kotula, Rose, Pierson, & Camp, 1997). Bacterial and fungal cells adhered to the surface of the sponge may have also limited the efficacy of the bleach and prevented penetration to microorganisms in the interior of the sponge during the treatment time. Bacterial cells may have formed biofilms, and these exopolysaccharide layers may have prevented the hypochlorite from killing microorganisms on or in the sponges (Ryu & Beuchat, 2005). Other workers have determined that concentrations of an antibacterial dishwashing soap (2–4%) that were effective in killing *E. coli, S.* Enteriditis, *Staphylococcus aureus,* and *B. cereus* in suspension were ineffective in killing these bacteria on used sponges (Kusumaningrum, van Putten, Rombouts, & Beumer, 2002). The presence of food residues in sponges increased survival of all of these bacteria except *B. cereus* when compared to survival in sponges that did not contain food residues.

Lemon juice was chosen as a treatment in this experiment because of the low pH (pH 2.9), its widespread availability, and because its lack of toxicity as a disinfectant. Acidic treatments have long been considered effective antimicrobial strategies (Davidson, 1999). The lack of efficacy displayed by 10% bleach and lemon juice may have been due to insufficient contact time.

Placing sponges in a dishwasher and microwave were the most effective methods to kill microorganisms. These findings concur with previous work stating the killing of microbes due to microwave treatment. Previous studies have shown that a 99.1% inactivation of sponges placed in a wastewater solution containing 3.5×10^7 CFU/100 ml of total bacteria was achieved after microwave treatments for 1 min in household microwave oven (Park, Bitton, & Melker., 2006). This same work showed that 30 s was sufficient to inactivate 100% of *E. coli* and total coliforms after sponges were soaked in solutions containing populations of 9×10^4 CFU of *E. coli*/100 ml and 2.2×10^6 CFU total coliforms/100 ml.

Microwave treatments of Gram positive and negative bacterial cells may result in different mechanisms of microbial death. Inactivation of *E. coli* and *Bacillus subtilis* bacteria were similar (ca. 5 log CFU/ml) when microwave treatment resulted in an ultimate temperature of 80 °C of the suspension (Woo, Rhee, & Park, 2000). Woo et al. (2000) also observed that suspensions of *E. coli* cells displayed more extracellular protein (as measured by absorbance at 280 nm after microwave treatment) than those of *B. subtilis*, indicating that *E. coli* cells may suffer more sub-lethal injury than *B. subtilis* cells. Conversely, cell suspensions of *B. subtilis* showed greater loss of nucleic acids than cell suspensions of *E. coli*, indicating that the membrane integrity of *B. subtilis* cells may be damaged by microwave treatments (Woo et al., 2000). Varied mechanisms of inactivation by microwave heating may be due to structural differences in gram positive and Gram negative bacteria. Other work has shown that although microwave irradiation and conventional heating produce the same levels of inactivation of *B. subtilis* spores, spores treated by microwave irradiation leaked no dipocolinic acid (DPA), while conventionally heated spores leaked more DPA (Celadroni et al., 2004). The changes in the biochemical composition of the spores upon exposure to microwaves or heat indicate that the heat generated by microwaving may not be the sole basis for inactivation of bacterial spores; changes in the spore can be attributed to microwave treatment as well. In our study, the total aerobic bacterial populations may have been inactivated by a combination of these mechanisms.

To our knowledge, this is the first study that examined the inactivation yeasts and molds in sponges. Levels of inactivation were similar to those observed for total aerobic bacteria, indicating that microwave and dishwashing treatments may reduce the numbers of spoilage microorganisms that can contaminate household kitchens. While microbial death may be attributed to a combination of microwave treatment and heat as proposed by other authors (Celadroni et al., 2004), differences in cellular structure may impact the specific mechanism of inactivation of fungal microorganisms by microwave treatment.

Dishwashing was more effective than any chemical treatment in killing microorganisms. Because our treatments did not include dishwashing detergent, we attribute the killing of microorganisms to the mechanical action of hot water applied during the washing and rinsing, the longer exposure time, and the heat applied during the drying cycle. Although microwaving provides similarly effective reductions of microorganisms on sponges, dishwashing may provide longer contact times at elevated temperatures. This may be more effective in killing heat-resistant bacterial spores and yeasts and molds that may contribute to spoilage of foods. More investigation is warranted on this particular topic.

In our study, as in the work of others (Park et al., 2006), wet sponges were placed in the microwave oven prior to heating. Water in the sponge may generate steam inside the sponge, killing microorganisms in the interior of the sponge. Wetting sponges before placing then in the microwave oven is also a necessary safety precaution. Placing dry sponges or those containing metallic scrub pads in the microwaves is a potential fire hazard. Sponges in our study did not have scrub or scouring pads. Sponges that contain metallic pads are not appropriate for microwave disinfection and should be placed in a dishwasher for disinfection.

Disinfection of sponges may be one aspect of kitchen hygiene that decreases the risk of foodborne illness in the home. Several studies have shown that targeted disinfection was the most

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effective method to reduce the risk of foodborne illness in households. Rinsing surfaces after contact with contaminated food reduced populations of *Camplyobacter*, although low levels of *Salmonella* persisted (Cogan, Slader, Bloomfied, & Humphrey, 2002). Barker, Naeeni, and Bloomfield (2003) showed that a combination of anionic detergents and 5000 ppm hypochlorite solution was the most effective method to reduce the probability of *Salmonella* contamination from various food contact surfaces. Other workers have shown that fecal coliform, coliform and heterotophic bacterial populations were successively reduced by a targeted and regular cleaning and disinfection regimen (Rusin et al., 1998). Structured disinfectant use immediately following the contamination of surfaces with foods or hands reduces bacterial counts significantly over irregular use (Josephson et al., 1997).

Disinfecting wet kitchen sponges by microwaving or dishwashing provides a fast and effective method to improve household kitchen hygiene. Chemical treatments to kill microorganisms in or on kitchen sponges proved less effective than placing sponges in a microwave oven or dishwasher. Disinfecting kitchen sponges through these means may provide one component of a kitchen hygiene plan that may reduce spoilage of foods and foodborne illness in the home.

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